MEMORY, 2010, 18 (8), 822–830

Psychology Press
Taylor & Francis Group

The effect of articulatory suppression on implicit and explicit false memory in the DRM paradigm

Ilse Van Damme, Jan Menten, and Géry d'Ydewalle
University of Leuven, Belgium

Several studies have shown that reliable implicit false memory can be obtained in the DRM paradigm. There has been considerable debate, however, about whether or not conscious activation of critical lures during study is a necessary condition for this. Recent findings have revealed that articulatory suppression prevents subsequent false priming in an anagram task (Lövdén & Johansson, 2003). The present experiment sought to replicate and extend these findings to an implicit word stem completion task, and to additionally investigate the effect of articulatory suppression on explicit false memory. Results showed an inhibitory effect of articulatory suppression on veridical memory, as well as on implicit false memory, whereas the level of explicit false memory was heightened. This suggests that articulatory suppression did not merely eliminate conscious lure activation, but had a more general capacity-delimiting effect. The drop in veridical memory can be attributed to diminished encoding of item-specific information. Superficial encoding also limited the spreading of semantic activation during study, which inhibited later false priming. In addition, the lack of item-specific and phenomenological details caused impaired source monitoring at test, resulting in heightened explicit false memory.

Keywords: DRM paradigm; Implicit memory; Explicit memory; Articulatory suppression; Divided attention.

The "DRM" paradigm (Deese, 1959; Roediger & McDermott, 1995) is a widely used research method to investigate the occurrence of false memories in the laboratory. Participants are asked to study lists of words (e.g., *bed, rest, awake, tired, dream, night,* etc.), which are all semantically related to a critical, but non-presented, lure word (e.g., *sleep*). In subsequent tests of memory, they erroneously identify the critical lure word as if it was presented: Both false recall and false recognition have been shown to occur at remarkably high rates, with probabilities similar to the probability of recalling/recognising presented list words (see Gallo, 2006, for a review).

Explanations are typically provided by two main theories. First, according to the "activation-monitoring" account (Roediger & McDermott, 1995, 2000), critical lures may be mentally activated during study (i.e., as an implicit associative response or "IAR"; Underwood, 1965), either through the unconscious spreading of activation or coming to mind consciously. On a subsequent memory test, participants are confronted with a source-monitoring problem (see Johnson, Hashtroudi, & Lindsay, 1993), in which they need to distinguish between items that were actually studied and items that were merely mentally activated during study. Confusion regarding the origin of the items (i.e., source confusion) may lead them to mistakenly recollect the critical lure as being part of the study list, creating a false memory. Second, according to the "fuzzy-trace" theory (e.g., Brainerd & Reyna, 1998, 2002), illusory memories arise because of their

Address correspondence to: Ilse Van Damme, Department of Psychology, University of Leuven, Tiensestraat 102, B-3000 Leuven, Belgium. E-mail: ilse.vandamme@psy.kuleuven.be

The present experiment was carried out by the second author in fulfilment of a master's thesis at the University of Leuven under supervision of both the other authors. Ilse Van Damme is a postdoctoral researcher of the Research Fund K.U.Leuven.

http://www.psypress.com/memory DOI:10.1080/09658211.2010.509733

consistency with the "gist" of the study lists. Both "verbatim" traces and "gist" traces are stored in parallel during the study phase. Whereas the former preserve specific information about the identity of each item, the latter capture the general meaning and interpretations invoked by the studied information. In the DRM paradigm strong gist traces will be formed, because of the high levels of semantic overlap between the list words. At test, the retrieval of gist traces may generate meaning-consistent intrusions and false alarms. The retrieval of verbatim traces, on the other hand, can inhibit false memory through "recollection rejection".

Although the majority of DRM studies have focused on explicit memory tasks such as free recall and old/new recognition, implicit memory tests have recently also attracted the interest of false memory researchers. Implicit memory differs from explicit memory in that there is no reference to past learning, and therefore it reflects automatic rather than controlled retrieval of information from the study phase (Graf & Schacter, 1985). By now, several studies have convincingly shown that implicit *false* memory, or priming for non-studied critical lure words, can be obtained in the DRM paradigm (McDermott, 1997; McKone & Murphy, 2000; Smith, Gerkens, Pierce, & Choi, 2002; Tajika, Neumann, Hamajima, & Iwahara, 2005; Tse & Neely, 2005; Van Damme & d'Ydewalle, 2009a; however, see also Hicks & Starns, 2005; McBride, Coane, & Raulerson, 2006; Zeelenberg & Pecher, 2002). One of the oldest and most well known implicit memory tests is word stem completion (e.g., Graf, Squire, & Mandler, 1984). In such a test, participants are presented with three letters and asked to produce the first word that comes to mind beginning with these letters. When target words were studied in a preceding experimental phase, the chances of these being generated at test are significantly greater than in a control condition in which they were not studied. This facilitation effect is generally referred to as "priming". In a DRM word stem completion task, *false* priming reflects the enhanced tendency to complete stems to critical lures related to studied lists, as compared to the baseline completion rate for lures related to non-studied lists.

Whereas veridical priming merely requires adequate encoding of the to-be-studied list words, false priming can occur only if the semantic relationships between the study words are properly encoded. There has been some debate, however, about the way in which this relational encoding (cf. Hunt & Einstein, 1981; Hunt & McDaniel, 1993) occurs. In line with the activation-monitoring account, several authors have claimed that conscious activation of the critical lure word is required to obtain implicit false memory.[1] McDermott (1997), for instance, found priming for critical lures in word stem and word fragment completion tasks (see also McKone & Murphy, 2000), and argued that—as such tests only show priming following lexical activation of the words involved—implicit false memory should be attributed to conscious activation of critical lures during study. Meade, Watson, Balota, and Roediger (2007) demonstrated that purely automatic activation processes in the DRM paradigm are only short-lived, and reasoned that findings of significant implicit false memory must therefore be due to repetition priming (rather than semantic priming), elicited by conscious activation of the lures during study.

Dewhurst, Barry, and Holmes (2005), on the other hand, found that conscious generation of associations during the study phase only affected later false "Remember" responses, but did not affect later false "Know" responses (procedure cf. Tulving, 1985). According to the authors, this suggests that covert verbal responses are required to remember specific study details, whereas the automatic spreading of activation is sufficient to just "know" that the word was studied (see also Kawasaki & Yama, 2006). Accordingly, Van Damme and d'Ydewalle (2010) recently obtained evidence that conscious lure generation does indeed contribute to explicit false memory, but does not show any association with implicit false memory, both in amnesic patients and in healthy controls.

In order to directly investigate the necessity of conscious lure activation for priming of critical lures, Lövdén and Johansson (2003) used articulatory suppression during the study phase and subsequently tested memory by means of an (implicit) anagram task. They reasoned that, if covert verbal responses contribute to implicit false memory, suppression would interfere with these verbal responses, and the false priming effect would be reduced. Participants were asked to continuously utter the irrelevant word "Coca-Cola" while studying DRM word lists. Afterwards, they were to solve anagrams corresponding to

[1] However, it should be noted that according to activation-monitoring theory, both conscious and unconscious lure activation are considered likely.

both studied words and critical lures, and to rate how difficult each anagram would seem to other participants. The same findings were obtained for both measures: Articulatory suppression resulted in non-significant levels of false priming. The authors therefore concluded that conscious activation of the lures is crucial to obtain reliable degrees of implicit false memory. However, they also noted that "it is conceivable that the suppression task had a more global capacity-delimiting effect" (p. 728), as it clearly divided attention during study.

The present experiment sought to replicate and extend Lövdén and Johansson's (2003) findings to a word stem completion task. The effect of articulatory suppression on explicit false memory was also examined, in order to further clarify the role of conscious lure activation. On the one hand, several studies have provided evidence for an association between the generation of critical lures and an increased likelihood of false recall/recognition (e.g., Goodwin, Meissner, & Ericsson, 2001; Marsh & Bower, 2004). Hence, if prevention of conscious lure activation was the (only) underlying factor inhibiting implicit false memory in Lövdén and Johansson, articulatory suppression should also be expected to inhibit explicit false memory. On the other hand, if a more global factor, such as divided attention, was responsible for the effect, an increase in explicit false memory with articulatory suppression should rather be expected: Pérez-Mata, Read, and Diges (2002) provided evidence that false recall increases when attention is divided with secondary task performance during study (see also Dewhurst et al., 2005; Dewhurst, Barry, Swannell, Holmes, & Bathurst, 2007). Importantly, their results suggested that the secondary task did not necessarily reduce the (conscious or unconscious) elicitation of associative responses, but rather prevented participants from encoding, monitoring, or identifying the cognitive processes and phenomenological experiences accompanying such associations. This reduction in distinctive, item-specific, and phenomenological information then complicated the discrimination of presented and non-presented items at test, leading to an increase in false recall. In other words, diminished recollection of item-specific information prevented the adequate monitoring (or recollection rejection) of participants' responses. In the present experiment a cued-recall test was adopted, so that the implicit and explicit test would differ only with respect to the retrieval instructions used.

METHOD

Participants

A total of 60 volunteers (27 female, 33 male) took part in the experiment. They were all native Dutch speakers and a majority of them were (under)graduate students. Their age ranged from 20 to 42 years, with an average of 29. They were tested individually.

Materials

Study lists. The materials used during the study phase consisted of 18 word lists, of which 9 were presented for study and 9 were used for test construction (counterbalanced). Following Roediger and McDermott (1995), each list was composed of 15 strong associations to one critical, non-presented, lure word. Words were selected based on Dutch word association norms, and were ordered by association frequency, with the strongest associations occurring first. Lists were taken from Van Damme and d'Ydewalle (2009a; Exp. 2), where they were created so they would meet the requirements for use with stem completion tasks (cf. McKone & Murphy, 2000). This implied that all critical lures and "list targets" were at least five letters long, and had distinct three-letter stems, with at least eight different possible completions.

One word from each list was selected to be the "list target" (i.e., the to-be-tested study word). This word was not allowed to appear in either the first two or the last two positions of the list. List targets were matched to critical lures on baseline completion rate ($M = 16\%$ and 21%) and word frequency ($M = 116$ and 117 occurrences per million, with frequencies counting based on the CELEX lexical database of Baayen, Piepenbrock, & Gulikers, 1995).

To allow for counterbalancing of studied versus non-studied materials, the 18 word lists were divided into two sets, roughly equated on four dimensions: word frequency and baseline completion rate of the lures, the probability of false recall, and the probability of false priming (as obtained in Van Damme & d'Ydewalle, 2009a, Exp. 1).

Test construction. Stem completion tests contained 36 three-letter stems, presented in a different random order for each participant. The stems originated from 9 studied words (i.e., list targets from the studied lists), 9 words that were semantically related to the studied words (i.e., critical lures from the studied lists), and 18 unstudied distractor words (i.e., 9 targets and 9 lures from the non-studied set). The latter were included to provide baseline scores, as well as to disguise the relationship between study and test phase and hence to reduce the chance of explicit contamination for participants in the implicit test condition (cf. McKone & Murphy, 2000).

Both study and test lists were visually presented, using black uppercase letters in the centre of a computer screen. E-prime was used for the presentation of all materials.

Design

Encoding condition (Full attention vs Divided attention) and Type of test (Implicit vs Explicit) were manipulated between-subjects, creating four conditions to which participants were randomly assigned (ensuring a group size of 15 people each). List status (Studied vs Unstudied) was varied within-subjects. In each condition, one set of nine lists was used for study. The remaining set of nine lists was not studied, but was used for construction of the word stem completion test. Each set was used equally often as studied and non-studied material, counterbalanced over participants and conditions. Within each set, the order of the lists was held fixed.

The experiment comprised three phases. The study phase involved the visual presentation of nine word lists, which were subsequently tested in a stem completion task with either explicit or implicit test instructions. The final phase of the experiment included a free recall test, followed by some questions about the retrieval strategy used during stem completion.

Procedure

Nine lists were visually presented, at a rate of 2 s per word. Lists were separated from each other by a 5-s appearance of an asterisk. In both encoding conditions, intentional learning instructions were administered to the participants. In the divided attention condition, participants were additionally asked to repeatedly say out loud the word "Coca-Cola", at a rate of approximately 2 times per word (i.e., articulatory suppression; cf. Lövdén & Johansson, 2003). After all lists had been studied, instructions for the word stem completion task appeared on the screen. Participants in the explicit test condition were informed that some of the stems would be originating from words they had seen during the study phase, whereas other stems would not. They were asked to complete stems only with words they remembered having seen, or otherwise to leave the stem blank. Participants in the implicit test condition were simply asked to complete each stem with the first word that came to mind. Following McKone and Murphy (2000), it was emphasised that the words used to complete the stems could come from anywhere, as long as they were provided as quickly as possible. Proper names were not allowed, and participants were told that it was acceptable to leave an item blank if nothing popped into mind immediately. Stems were presented one by one on the computer screen, with the experimenter writing down all responses.

After the stem completion task was finished, a final free recall test was given: Participants were asked to recall as many of the list words as they could still remember. The main reason of providing this task was to give participants in the implicit retrieval condition the opportunity to explicitly retrieve the studied words (in order to justify the intentional encoding instructions used), and hence to show what they were able to remember.

As a final stage of the experiment, participants were told that the experimenter had some remaining questions about the stems they had completed. Based on the memory strategies questionnaire developed by McKone and Murphy (2000), they were asked whether they deliberately tried to complete the stems with words they remembered from the study lists, or rather completed the stems with whatever word popped into their heads first. Of particular interest was whether participants in the implicit test condition would report using explicit retrieval. This was not the case. All participants reported to have used the strategy that was in line with the instructions provided to them. At the end of the experiment everyone was fully debriefed.

RESULTS

Stem completion data are presented in Table 1. Memory scores were obtained by subtracting the proportion of stems completed to targets/lures from non-studied lists (i.e., the baseline completion rate) from the proportion of stems completed to targets/lures from studied lists (cf. McKone & Murphy, 2000; Van Damme & d'Ydewalle, 2009a). Since free recall performance was contaminated by performance on the preceding stem completion tests, analyses on these data are not presented. The task's main purpose was to justify the intentional encoding instructions and to allow participants in the implicit stem completion condition to explicitly retrieve the studied information. An alpha level of .05 was used for all statistical tests.

Veridical memory for studied list words

A 2 (Encoding condition: Full vs Divided attention) × 2 (Test condition: Implicit vs Explicit) × 2 (List status: Studied vs Unstudied) mixed-factors analysis of variance was carried out on the stem completion rates for list targets. Significant main effects of Test condition, $F(1, 56) = 4.05$, $MSE = .02$, $p = .049$, $\eta_p^2 = .07$, and of List status, $F(1, 56) = 63.22$, $MSE = .03$, $p < .0001$, $\eta_p^2 = .53$, were qualified by a significant interaction, $F(1, 56) = 17.59$, $MSE = .03$, $p < .0001$, $\eta_p^2 = .24$. This reflected the fact that veridical memory scores (i.e., the difference between studied and unstudied lists) were larger under explicit than under implicit retrieval instructions. Simple main effects revealed that this could be attributed to a significant difference in stem completion rates for studied lists, $F(1, 56) = 19.92$, $p < .0001$, whereas there were no significant differences in baseline completion rates for unstudied lists (see Table 1). Hence, as could be expected, word stems originating from studied lists were completed correctly more frequently in an explicit than in an implicit memory test.

The interaction between List status and Encoding condition was marginally significant, $F(1, 56) = 2.45$, $MSE = .03$, $p = .12$, $\eta_p^2 = .04$, pointing to higher veridical memory scores in the full attention condition than in the divided attention condition (see Table 1). Simple main effects revealed that the effect of Encoding condition was significant for stems originating from studied lists, $F(1, 56) = 4.98$, $p = .03$, but not for the baseline completion rate for unstudied lists ($F < 1$). Hence, articulatory suppression inhibited correct completion of word stems from studied lists (regardless of the type of retrieval instructions). Due to this inhibition, implicit memory for list targets was no longer significant in the "suppressed" condition ($M = .05$), $t(56) = 0.88$, whereas it was significant in the full attention condition ($M = .17$), $t(56) = 2.88$, $p = .006$.

False memory for critical lure words

A 2 (Encoding condition) × 2 (Test condition) × 2 (List status) mixed-factors analysis of variance on the stem completion rates for critical lures revealed significant main effects of Test condition, $F(1, 56) = 8.85$, $MSE = .02$, $p = .004$, $\eta_p^2 = .14$, and of List status, $F(1, 56) = 91.08$, $MSE = .02$, $p < .0001$, $\eta_p^2 = .62$, which were involved in a significant two-way interaction, $F(1, 56) = 42.93$, $MSE = .02$, $p < .0001$, $\eta_p^2 = .43$. The three-way interaction between Encoding condition, Test condition, and List status was also significant, $F(1, 56) = 6.57$, $MSE = .02$, $p = .01$, $\eta_p^2 = .11$.

TABLE 1
Proportions of stems correctly completed to list targets and critical lures, as a function of encoding condition, test condition, and list status (with standard errors of the mean in parentheses)

	Implicit test			*Explicit test*		
	Studied	*Unstudied*	*Memory*	*Studied*	*Unstudied*	*Memory*
List targets						
Normal encoding	.30 (.04)	.13 (.03)	.17 (.05)	.47 (.05)	.08 (.03)	.39 (.06)
With suppression	.21 (.05)	.16 (.03)	.05 (.07)	.39 (.05)	.07 (.02)	.33 (.06)
Critical lures						
Normal encoding	.27 (.04)	.12 (.04)	.15 (.05)	.44 (.05)	.08 (.03)	.36 (.07)
With suppression	.20 (.03)	.19 (.03)	.01 (.05)	.52 (.04)	.04 (.02)	.48 (.03)

Memory scores were obtained by subtracting the proportion of stems completed to targets/lures from unstudied lists (i.e., the baseline completion rate) from the proportion of stems completed to targets/lures from studied lists.

Generally, false memory scores (i.e., the difference between studied and unstudied lists) were higher under explicit than under implicit retrieval instructions. The effect was larger in the divided attention condition than in the full attention condition, however. This could be attributed to the fact that articulatory suppression *inhibited* implicit memory for critical lures, $t(56) = 1.91$, $p = .06$, while it *enhanced* explicit memory for critical lures, $t(56) = 1.71$, $p = .09$ (see Table 1). Critically important, and in line with the expectations, planned comparisons confirmed that implicit memory for critical lures was significant only following regular encoding ($M = .15$), $t(56) = 2.85$, $p = .006$, but not following ''suppressed'' encoding ($M = .007$), $t(56) = 0.14$. In the divided attention condition, virtually no false memories were obtained.

Summary

In accordance with the nature of the retrieval instructions, word stems from studied lists were completed correctly more frequently in the explicit than in the implicit test. Articulatory suppression inhibited veridical memory, regardless of the test instructions used. It had opposite effects on implicit and explicit false memory, however: Whereas suppression during encoding eliminated implicit false memory, it heightened explicit false memory.

DISCUSSION

In the present experiment a word stem completion task was used to assess both implicit and explicit memory following either regular or ''suppressed'' encoding. Based on Lövdén and Johansson (2003), articulatory suppression was expected to inhibit implicit false memory, and the results supported this expectation: Suppression at study effectively eliminated false memory in the implicit stem completion task. With respect to explicit false memory, however, different expectations could be formulated based on the factor supposed to be underlying the effect of articulatory suppression. On the one hand, if mere prevention of conscious lure activation was the underlying factor inhibiting implicit false memory, then articulatory suppression should also inhibit explicit false memory: Several studies have provided evidence for an association between critical lure activation and the likelihood of explicit false memory (e.g., Goodwin et al., 2001; Marsh & Bower, 2004). However, if a more global factor, such as divided attention, was responsible for the effect, an increase in explicit false memory with articulatory suppression should be obtained: False recall has been shown to increase with secondary task performance (Pérez-Mata et al., 2002; see also Dewhurst et al., 2005, 2007).

With respect to implicit false memory, Lövdén and Johansson's (2003) results were replicated and extended to the word stem completion task: Priming for critical lures was only significant following regular encoding, but approximated zero following ''suppressed'' encoding. In contrast to Lövdén and Johansson, however, similar results were obtained for implicit veridical memory: Priming for list targets was also significant only following regular encoding, but not following ''suppressed'' encoding. This points to the conclusion that articulatory suppression did not just eliminate conscious lure activation, but hindered encoding in a more general way. It also suggests that, in word stem completion, priming for studied words is (at least partly) based on conceptual processes: Purely perceptual implicit tests are generally unaffected by manipulations of divided attention during the study phase (e.g., Mulligan, 1998). Our finding is consistent with previous research showing that word stem completion is not a regular perceptual test, but also has a conceptual component (e.g., Brown & Mitchell, 1994; Carlesimo, 1994; Carlesimo et al., 1999; Horton, Wilson, & Evans, 2001; Schwartz, 1989; see also McKone, 2004).

Importantly, articulatory suppression produced opposite effects on false memory under explicit and implicit retrieval instructions: Whereas it *decreased* false priming, it *increased* the level of explicit false memory.[2] The opposite nature of these effects again strongly indicates that articulatory suppression did not merely eliminate conscious lure activation, but had a more general capacity-delimiting effect: Continuously saying ''Coca-Cola'' during study can be seen as a secondary task, causing divided attention. The cued stem completion test used in the present study behaved exactly like the free recall tests used in previous studies. Pérez-Mata et al. (2002)

[2] Considered separately, both effects were only marginally significant, but the size of the interaction effect lends strong support to their opposite nature.

showed that false recall is increased when participants perform a secondary task during study. In addition, using tasks similar to the one in the present study (i.e., articulatory suppression and random number generation), Dewhurst et al. (2005, see also 2007) obtained an increase in false recall, as well as an increasing number of ''Know'' judgements of critical items in an old/new recognition task. In both studies, ''Remember'' judgements of studied items as well as critical lures decreased under secondary task conditions. The latter also points to heightened uncertainty and diminished recollection of phenomenological information associated with both studied items and critical lures.

As argued by Pérez-Mata et al. (2002), the effect on free recall suggests that the secondary task prevented participants from encoding the phenomenological information accompanying both studied and associated items, as a result of which monitoring was impaired: A reduction in distinctive, item-specific information complicated the discrimination of presented and non-presented items at test, leading to an increase in explicit false memory. The decrease in veridical memory obtained in the present study could also be attributed to problematic item-specific recollection. However, to explain the decrease in *implicit* false memory, an additional step in the explanation is needed: As list words were processed more superficially in the divided attention or ''suppressed encoding'' condition, this most likely inhibited the spreading of semantic activation from the list words to each other and to other words/concepts in memory.

In sum, as attention is divided, words are processed more superficially. This leads to impaired item-specific encoding (and therefore a decrease in veridical memory), diminished spreading of activation (and therefore a decrease in false priming), and impaired monitoring of the responses coming to mind during the test phase (and therefore an increase in explicit false memory): When explicitly retrieving items based on the cues provided, participants will be unable to identify the source of the critical lures and to judge them as non-studied. This can be framed within both the activation-monitoring account and fuzzy-trace theory: Suppressing gist-based false memories through the recollection of verbatim information on the one hand, and successful source monitoring on the other hand can be considered complementary or even identical phenomena (see also Van Damme & d'Ydewalle, 2009b). It is not necessary, however, to call for the presence/absence of *conscious* lure activation to explain the differences between conditions. The findings can entirely be attributed to superficial encoding and therefore diminished spreading of semantic activation. Hence, the present results definitely do *not* speak against the assumption that conscious lure activation is irrelevant for implicit false memory (see Van Damme & d'Ydewalle, 2010).

The above explanation emphasises the combination of diminished spreading of activation and impaired source monitoring, both resulting from a decrease in item-specific encoding. As argued by Dewhurst et al. (2007), however, the increase in explicit false memory might also reflect an attempt to compensate for poor memory by a shift in response criterion (e.g., Miller & Wolford, 1999). When participants perceive the study phase as being more difficult, they might adopt a more liberal response criterion during the test phase. If a stem completion then comes to mind that is related to one of the studied lists, they are more inclined to use that item as a response. Hence, the more liberal the criterion, the more explicit false memories obtained. However, this notion is difficult to reconcile with the fact that explicit memory for studied words *decreased* with articulatory suppression. As studied words also fit within the themes of the lists, correct cued recall should also increase with a more liberal response criterion (although probably to a lesser extent), or at the very least stay the same and not show a decrease. Evidence for such reasoning has been obtained by both Gallo, Roberts, and Seamon (1997) and McDermott and Roediger (1998), showing that lowering response criteria by warning participants about the nature of the task affected hit rates as well as false alarm rates. In other words, the fact that the present manipulation produced opposite effects on veridical and false cued-recall is difficult to explain solely in terms of a shift in response criteria (see Roediger & McDermott, 1999). A decrease in item-specific encoding and therefore impaired source monitoring, on the other hand, can explain both tendencies. The secondary task (i.e., articulatory suppression) prevented the encoding of both item-specific and phenomenological information, directly causing a decrease in (both implicit and explicit) veridical memory. Due to the superficial level of encoding, the spreading of semantic activation in memory was also inhibited, which eliminated false priming. In addition, the lack of item-specific and phenomenological details caused impaired source monitoring, resulting in heightened levels of explicit false memory.

Manuscript received 24 February 2010
Manuscript accepted 6 July 2010
First published online 27 September 2010

REFERENCES

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The CELEX lexical database [CD-Rom]*. Philadelphia, PA: University of Pennsylvania, Linguistic Data Consortium.

Brainerd, C. J., & Reyna, V. F. (1998). When things that were never experienced are easier to "remember" than things that were. *Psychological Science*, *9*, 484–489.

Brainerd, C. J., & Reyna, V. F. (2002). Fuzzy-trace theory and false memory. *Current Directions in Psychological Science*, *5*, 164–169.

Brown, A. S., & Mitchell, D. B. (1994). A re-evaluation of semantic versus nonsemantic processing in implicit memory. *Memory & Cognition*, *22*, 533–541.

Carlesimo, G. A. (1994). Perceptual and conceptual priming in amnesic and alcoholic patients. *Neuropsychologia*, *32*, 903–921.

Carlesimo, G. A., Mauri, M., Marfia, G. A., Fadda, L., Turriziani, P., & Caltagirone, C. (1999). Lexical and conceptual components of stem completion priming in patients with Alzheimer's disease. *Neuropsychologia*, *37*, 1049–1059.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, *58*, 17–22.

Dewhurst, S. A., Barry, C., & Holmes, S. J. (2005). Exploring the false recognition of category exemplars: Effects of divided attention and explicit generation. *European Journal of Cognitive Psychology*, *17*, 803–819.

Dewhurst, S. A., Barry, C., Swannell, E. R., Holmes, S. J., & Bathurst, G. L. (2007). The effect of divided attention on false memory depends on how memory is tested. *Memory & Cognition*, *35*, 660–667.

d'Ydewalle, G., & Van Damme, I. (2007). Memory and the Korsakoff syndrome: Not remembering what is remembered. *Neuropsychologia*, *45*, 905–920.

Gallo, D. A. (2006). *Associative illusions of memory: False memory research in DRM and related tasks*. New York: Psychology Press.

Gallo, D. A., Roberts, M. J., & Seamon, J. G. (1997). Remembering words not presented in lists: Can we avoid creating false memories? *Psychonomic Bulletin & Review*, *4*, 271–276.

Goodwin, K. A., Meissner, C. A., & Ericsson, K. A. (2001). Toward a model of false recall: Experimental manipulation of encoding context and the collection of verbal reports. *Memory & Cognition*, *29*, 806–819.

Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *11*, 501–518.

Graf, P., Squire, L. R., & Mandler, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 164–178.

Hicks, J. L., & Starns, J. J. (2005). False memories lack perceptual detail: Evidence from implicit word-stem completion and perceptual identification tests. *Journal of Memory and Language*, *52*, 309–321.

Horton, K. D., Wilson, D. E., & Evans, M. (2001). Measuring automatic retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*, 958–966.

Hunt, R. R., & Einstein, G. O. (1981). Relational and item-specific information in memory. *Journal of Verbal Learning and Verbal Behavior*, *20*, 497–514.

Hunt, R. R., & McDaniel, M. A. (1993). The enigma of organization and distinctiveness. *Journal of Memory and Language*, *32*, 421–445.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*, 3–28.

Kawasaki, Y., & Yama, H. (2006). The difference between implicit and explicit associative processes at study in creating false memory in the DRM paradigm. *Memory*, *14*, 68–78.

Lövdén, M., & Johansson, M. (2003). Are covert verbal responses mediating false implicit memory? *Psychonomic Bulletin & Review*, *10*, 724–729.

Marsh, E. J., & Bower, G. H. (2004). The role of rehearsal and generation in false memory creation. *Memory*, *12*, 748–761.

McBride, D. M., Coane, J. H., & Raulerson, B. A., III (2006). An investigation of false memory in perceptual implicit tasks. *Acta Psychologica*, *123*, 240–260.

McDermott, K. B. (1997). Priming on perceptual implicit memory tests can be achieved through presentation of associates. *Psychonomic Bulletin & Review*, *4*, 582–586.

McDermott, K. B., & Roediger, H. L., III (1998). Attempting to avoid illusory memories: Robust false recognition of associates persists under conditions of explicit warnings and immediate testing. *Journal of Memory and Language*, *39*, 508–520.

McKone, E. (2004). Distinguishing true from false memories via lexical decision as a perceptual implicit test. *Australian Journal of Psychology*, *56*, 42–49.

McKone, E., & Murphy, B. (2000). Implicit false memory: Effects of modality and multiple study presentations on long-lived semantic priming. *Journal of Memory and Language*, *43*, 89–109.

Meade, M. L., Watson, J. M., Balota, D. A., & Roediger, H. L. III (2007). The roles of spreading activation and retrieval mode in producing false recognition in the DRM paradigm. *Journal of Memory and Language*, *56*, 305–320.

Miller, M. B., & Wolford, G. L. (1999). Theoretical commentary: The role of criterion shift in false memory. *Psychological Review*, *106*, 398–405.

Mulligan, N. W. (1998). The role of attention during encoding in implicit and explicit memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 27–47.

Pérez-Mata, M. N., Read, J. D., & Diges, M. (2002). Effects of divided attention and word concreteness on correct recall and false memory reports. *Memory*, *10*, 161–177.

Roediger, H. L., III, & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 803–814.

Roediger, H. L., III, & McDermott, K. B. (1999). False alarms about false memories. *Psychological Review*, *106*, 406–410.

Roediger, H. L., III, & McDermott, K. B. (2000). Tricks of memory. *Current Directions in Psychological Science*, *9*, 123–127.

Schwartz, B. L. (1989). Effects of generation on indirect measures of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 1119–1128.

Smith, S. M., Gerkens, D. R., Pierce, B. H., & Choi, H. (2002). The roles of associative responses at study and semantically guided recollection at test in false memory: the Kirkpatrick and Deese hypotheses. *Journal of Memory and Language*, *47*, 436–447.

Tajika, H., Neumann, E., Hamajima, H., & Iwahara, A. (2005). Eliciting false memories on implicit and explicit memory tests after incidental learning. *Japanese Psychological Research*, *47*, 31–39.

Tse, C., & Neely, J. H. (2005). Assessing activation without source monitoring in the DRM false memory paradigm. *Journal of Memory and Language*, *53*, 532–550.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychologist*, *26*, 1–12.

Underwood, B. J. (1965). False recognition produced by implicit verbal responses. *Journal of Experimental Psychology*, *70*, 122–129.

Van Damme, I., & d'Ydewalle, G. (2009a). Implicit false memory in the DRM paradigm: Effects of amnesia, encoding instructions, and encoding duration. *Neuropsychology*, *23*, 635–648.

Van Damme, I., & d'Ydewalle, G. (2009b). Memory loss versus memory distortion: The role of encoding and retrieval deficits in Korsakoff patients' false memories. *Memory*, *17*, 349–366.

Van Damme, I., & d'Ydewalle, G. (2010). Incidental versus intentional encoding in the Deese-Roediger-McDermott paradigm: Does amnesic patients' implicit false memory depend on conscious activation of the lure? *Journal of Clinical and Experimental Neuropsychology*, *32*, 536–554.

Zeelenberg, R., & Pecher, D. (2002). False memories and lexical decision: Even twelve primes do not cause long-term semantic priming. *Acta Psychologica*, *109*, 269–284.